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No. IV.

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*Geological Account of the Valley of the Ohio : in a Letter from Daniel Drake, M. D. to Joseph Correa de Serra.—  
Read 7th Nov. 1818.*

*Cincinnati, Ohio, 1st October, 1817.*

SIR,

I FEAR that you have long since thought me inattentive to your polite request, that I should send you a copy of the *Vertical Chart* which I had sketched of the valley of the Ohio river at this place. But so far from being regardless of your wish, an over anxious desire to gratify it fully has been the cause of my delay. I entertained, till lately, the hope of collecting such facts as would lead to some certain conclusions relative to the epochs and causes of this great excavation ; but constant ill health, and an increase of my ordinary engagements, have left me so small a portion of time for research or reflection on extra-professional subjects, that I no longer expect to do more than give you an evidence of my disposition to amuse you.

Notwithstanding the delay of so many months, the graphic execution of the present copy is very little better than the original sketch which you saw in Philadelphia. It is, however, I trust, as accurate a representation as the perforations and admeasurements hitherto made at this place will admit. The elevations and projections are of course on different scales ; which gives to the slopes a greater perpendicularity than is correct ; but of this, and the other effects

produced by combining two proportions in the same delineation, it is superfluous for me to apprise you.

You are, Sir, already apprised, from personal observation, that the alluvial formation of which I have here given you the profile, is divided near its middle by the Ohio river, and extends about a mile from either shore, exclusively of the valley of Licking river to the south, and that of Mill creek to the north-west. When viewed from any of the surrounding hills, this hollow, or expansion, appears nearly of a rhomboidal figure, and its area is equal, by estimation, to eight square miles. I have seen several places, particularly at the junction of other rivers with the Ohio, where its valley is dilated to the same extent; but, in general, it does not exceed half this width; and the current, instead of traversing the alluvial grounds in the centre, meanders from side to side, alternately approaching the hills of Ohio and Kentucky. Thus the earthy plains of one side are generally opposed to the rocky slopes of the other. Many of the former (in our provincial dialect termed *bottoms*) are so low as to suffer frequent inundation; but at Cincinnati and various other places, some of them rise fifty or even a hundred feet above the highest level of the river. The ascent to this elevation is generally over two or three successive terraces, mounting between twenty and fifty feet above each other, so as to exhibit, when viewed from the stream, the elevations of a vast amphitheatre. The alluvial platforms along many of the smaller rivers on the north side of the Ohio, are arranged on the same plan; but the ascent from one to the other is generally less than that stated for the principal valley. Very few of the slopes, or *taluses*, which we see in descending the Ohio, are entirely covered with vegetables, and most of them, towards their summits, exhibit naked perpendicular cliffs, which are yet suffering disintegration, and sufficiently indicate, that the last retreat of the sea was not at a *very* remote period. From an inspection of these precipices, and of the strata which are exposed to view in the bed of the river at low water, it appears probable that the floëts shell limestone

of this quarter has experienced no disruption, for it has certainly suffered no elevation nor *bouleversement*. It still retains its horizontal position, or at most, varies from that in too slight a degree to warrant the conclusion, unequivocally, that the valley was formed either by an explosion and consequent rupture of the strata, or by their subsidence. How far their shrinking, from exsiccation, after being laid bare, may have contributed to its formation, I am not prepared to decide.\* A hollow produced, however, by any of these causes, except perhaps the last, would, I apprehend, be a deep and irregular fissure, instead of a broad and shallow trench, like that of the Ohio.

To what agent, then, shall we ascribe this great excavation? It is obviously impossible to answer this question with certainty; but it would not perhaps be rash to conclude that, in its formation, there were two or three distinct and successive stages or epochs. Some kind of channel and some degree of declivity must have preceded the commencement of every river; . . . but whether this and the other initial excavations were produced by unknown causes which acted on the bottom of the sea, or by a violent elevation of that bottom at the time of its deliverance from the waters, I shall not offer a conjecture. Whatever may have been the *first* agent, the *second* undoubtedly was the vast and resistless currents that must have attended the transportation of the ocean from one bed to another. To these currents, acting upon strata not yet perhaps fully consolidated, and unsupported by the roots of a single plant, we may fairly attribute most of the extent and form of the present vallies.

By supposing the change of place in the sea to have been produced by the elevation of this continent, we can account in some degree for those irregularities of surface which originally directed the retiring waters into their present courses; but the uniform levelness and extensive continuity of our se-

\* See Mr. Longmaire's Speculations in the Annals of Philosophy, Vol. 78.

condary formations, the comparative evenness of the surface, and the entire absence of primitive transition and ancient floëts rocks *in situ*, would seem to render it probable that the retreat of the sea was occasioned by the sinking of another continent, and not by the elevation of this. Which of these alternatives, however, may have occurred, I shall not further attempt to inquire ; but assume the hypothesis, that a great convulsion destroyed the relative elevation of this region, and that which is now covered by the Gulph of Mexico and the Carribean sea, from Florida to Cumaria ;\* in consequence of which the ocean flowed hence into its new bed, in the *direction* of the Mississippi. The valley of that river was of course the first excavation effected by the retiring waters. To this primary canal the others succeeded in the order of their distance from the common *embouchure*. These vast operations continued in all probability for several ages, during which the valleys constantly became deeper, wider, and more symmetrical. Meanwhile the *debris* of the various strata, at that time perhaps more friable than at present, were rolled, polished by attrition, intermixed, and accumulated in the lowest situations.

The currents, which I am supposing to have effected this great work, seem not to have been equally strong over every part of the country. To the south of the river the valleys have less symmetry, exhibit less strikingly the impress of aqueous currents, and contain but few rolled pebbles. On the contrary, we observe in that region numberless excavations which seem not referable to any action of the retiring waters, or of the subsequent rains. In some parts of Kentucky, these hollows, or *ravines*, are from one to two hundred feet in depth, have steep acclivities, and are so narrow at bottom, that their transverse sections would very much resemble in figure and magnitude the same sections of the hills they separate. It is difficult to believe these to have

\* We may suppose this to have been either a distinct and limited convulsion, or a part of that general revolution which laid bare the existing continents of the globe.

been cut down by currents, and it would, I think, be more rational to regard them as the signs and products of a forcible elevation of that quarter, or else as cracks from the drying of the strata after being left by the sea, or even as inequalities formed simultaneously with the deposition of the strata where they are found. At some period subsequent to the complete retirement of the waters of the ocean, a third era in the formation of our valleys seems to have commenced. The rivers became much reduced in size, and began to flow in narrow channels, supported by the alluvion which they had previously transported. From this time, they appear to have effected but little horizontal detrition. *They have increased the depth of their beds, but not widened their valleys.* The Ohio, as you may see by a reference to the Chart, has a channel below the bottom of the alluvial deposits, to which it is confined, when not swollen by rains. This, I apprehend, is its own work, and has been effected since the existing state of the surface of the continent was produced. In front of Cincinnati, the depth of this canal is between thirty and forty feet in the centre, and it becomes shallower as we approach either shore, apparently at the same rate at which the velocity of the current decreases, from the middle to the margins of the stream. This bed is doubtless becoming deeper; but the ratio of increase is extremely slow, as no abrasion takes place except when the momentum of the waters is augmented by floods, which are generally transient in their duration. At all other times, the velocity of the current at the bottom is a minimum, or approaching to it. This is obvious in summer and autumn, when the water is so low and transparent, that its bottom may be seen from the surface. It may then be observed, that the bed in many places, from side to side, is covered with rolled pebbles; and that the rocks, where not thus protected, are overspread with minute *algæ musci*, dead leaves, twigs, and other light bodies, which the gentlest current would sweep away. Now where there is no current, it is obvious there can be no detrition.

It is a common opinion of the people on the banks of the Ohio, that its waters were always the same in quantity, and formerly occupied, in succession, various parts of the valley, at much higher levels than at present. By this supposition they attempt to account for the alluvial deposits, which, in many places, arise, as already stated, to the height of several yards above the most elevated high water mark of these times. But the excavation underneath the ancient beds of alluvion is as deep as that beneath the recent ones, and with the exception of the narrow channel in which the river now flows, every part of the valley is equally profound; when therefore the former were accumulated, the waters extended from hill to hill, and constituted a vast river, which must have swollen at times more than a hundred feet above the greatest altitude of the present comparatively diminutive stream. No other supposition, it appears to me, can account for the great elevation of the older alluvial banks. An illustration of this, upon a small scale, is afforded by the little torrents which descend during a shower, from an eminence, along a pre-existing *gully*,\* where the declivity is great, and while the mass and motion of the waters are considerable, nothing is deposited; but as they decrease, the pebbles, mud, and light bodies, which are borne along, subside into beds, over which the reduced and narrow rivulet continues feebly to meander. The comparison cannot be extended any further; for a succeeding rain will deluge these little grounds, and perhaps raise them to a still greater height: but the causes which formerly spread the Ohio over the whole valley, have long since ceased to operate; and if its waters be not at this time diminishing, they are certainly not increasing.

I shall conclude this part of my letter with the following observations:—

1. The expansions in some parts of the valley of the Ohio, which I have conjectured were partly produced by

\* Used provincially.

causes that acted before the retreat of the sea, or by the convulsion which occasioned that event, must have constituted at one period a series of little lakes, which were gradually, by the action of the waters, formed into the present continued and irregular canal.

2. It has been already stated, that on the south side of the Ohio its tributary streams flow in deeper vallies than on the north. This is obvious from the difference in current, when low, of these two classes of rivers, and from the very different distances at which their waters are rendered stagnant by the floods of the Ohio. When this river is greatly swollen, the current in the Kentucky river is destroyed nearly to Frankfort, a distance of forty miles, while that of the Great Miami in this State, a river of almost the same magnitude, is not suspended for more than twelve or fifteen. The principal vallies of the north are, however, much wider than those of the south. If they were all fissures originally, those of the south were probably the deepest. The present difference in their width has perhaps arisen from the sides of the former being composed of hard limestone, with but thin inter-laminæ of argillaceous matter, while the rocky strata of the latter are widely separated by friable marl and slate clay. It would appear, that to the south the currents had produced more vertical, in the north more horizontal, attrition.

3. In the very extensive artificial excavations made into the old alluvial formation at this place, the only aquatic animal remains, either of the river or the sea, which have been discovered, except those detached from the flötz rocks, were the shells of a bivalve, which seems to be a species of *Mya* : but whether it inhabited the fresh or salt water, I am unable to decide. Hence it would seem that when these grounds were deposited, the waters had but few inhabitants. Those of the ocean had withdrawn, and those which the river now contains had not yet become its tenants. Whether this be admitted or not, it is certain that the alluvial deposits made at the present day are by no means free from river shells.



4. That the valleys of this quarter are not the work of causes which have acted regularly and unremittingly ever since the recession of the sea, but that there was a particular and distinct period of excavation, is rendered still more probable, by the fact, that their declivities are every where covered with a body of loam and soil: For while the causes which produced these slopes continued to act, it is impossible that mould or any loose matter should have been accumulated upon them.

5. What length of time has elapsed since the final descent of the ocean into its new bed, since the rivers completed the *lateral* excavation of their vallies, were reduced to their present size, and began to deposit the low and recent *bottoms*, I am not in possession any of data for determining. An accurate survey by us of those grounds, of the immediate and rocky channels of the streams, of the incomplete and increasing *taluses* of our hills, and of the vegetable mould which overspreads the face of the country, would furnish to a succeeding generation some important facts for an estimate of this kind. From the rate of advancement of the *downs* and natural sand *level* which border the southern shores of Michigan, and perhaps some of the other lakes, conclusions equally certain will hereafter, in all probability, be drawn.\* By a reference to the Chart, you will perceive the lateral extent and various elevations of the alluvial formation at this place. You may suppose the section to be

\* I do not know that these *downs* have been mentioned by any traveller or writer. I am informed by my friend Mr. William Harris, who was lately employed under the direction of the Surveyor General of the United States, in running the northern boundary line of this State, that they are found along the south eastern border of the lake for thirty or forty miles. In some places they extend two or three miles from the head. They are very numerous, of various shapes and sizes, and grouped in such a manner as to form basins or concavities, some of which are filled with water. Not a single rivulet flows from among them. There is very little soil spread over any of these hillocks, and part of them are quite destitute of vegetation. Others are thinly covered with small pine and oak trees. It is possible that this formation may have ceased growing, and that it cannot therefore serve as a natural chronometer.

made along Main Street in this town, and through the centre of Covington on the opposite side of the river, a short distance below the mouth of the Licking. It is necessary to consider yourself as placed west of this line, which is nearly on the meridian, with your face directed to the east, or up the river. From this position, it may be seen, that the plain, to the right hand, on the Kentucky side, has an elevation between that, which, in this town, we term the *bottom*, and that which is denominated the hill.

A very small part of the southern or Kentucky plain is liable to inundation, but the lower part of the northern was entirely overflowed in the year 1793, and has been partially covered two or three times since.\* These three tables differ somewhat in composition, as well as in elevation. That on which the opposite villages of Newport and Covington are built, is little else than a bed of sandy loam; to the greatest depths that it has yet been perforated. The bottom or lower plain on this side, is composed, in its superior parts, chiefly of loam and various coloured clays proper for bricks and coarse earthenware: in its inferior, of beds of strong *debris* consisting chiefly of primitive and transition gravel, which may be seen on the Covington side of the river, at the same depth. The upper table, or *hill*, consists chiefly of sand, gravel, and rolled pebbles, in some parts blended together, in others composing separate beds, the strata of which are either horizontal, or inclined and curved in various directions and degrees. Most of them *dip*, however, to the north and north west. It ought perhaps to be noted, that the sand, when in distinct beds, is generally underneath the pebbles. The greatest collection of the latter is in the upper parts of the table near its southern margin, or that which looks towards the river. Many openings have been made into this part of the plain, and it requires but the slightest inspection to perceive that it contains the wreck of various and very distinct strata. It is indeed an epitome of

\* It is proper to observe, that the corporation has lately thrown up a levee that will prevent the future encroachments of the waters.

all the formations of the northern part of the continent, a great natural cabinet at once rich, confused, and instructive. Its multifarious specimens may be arranged in the following manner :

1. Fragments of fossil wood, which have been dug up at various depths, from ten to ninety feet. They are not mineralised, and *appear* to have belonged to trees of the same species with some of those which grow in our existing forests. I have not detected among them any tropical plants.

2. Grey, siliceous, and calcareous sand, which composes a great portion of the plain, and has probably resulted from the destruction of arenaceous limestone rocks, many strata of which exist in this country to the north and east.

3. Veins of blue and yellow clay, afforded no doubt by the marl, which in many parts of the limestone tracts, separate the laminæ of that formation.

4. Rolled and angular fragments of blue shell limestone, detached from the strata of the surrounding hills. Many of these are large tabular masses, and seem to have been brought only a short distance. None of them indeed could have come down the river more than one hundred miles, as this variety does not extend beyond that limit to the east. They are very numerous.

5. Polished *debris* of that kind of grey sandy limestone which the Sciota and Little Miami rivers traverse near their sources, and which have evidently been rolled hither by the copious streams that formerly flowed in the valleys of those rivers. These fragments are as numerous as the last.\*

6. Rubble and boulders of grey variegated and micaceous sandstone, with minute fragments of coal, aluminous slate, and shivers, generally rendered smooth by attrition. These are from the country up the Ohio, where such strata are found *in place*. They are not so numerous as the two last.

7. Foreign or adventitious *debris*, consisting of granite of different colours, *gneiss*, *micaslate*, *hornblende*, *sienite*, *wacke*,

\* These, on account of the whiteness of the lime into which they burn, are collected and used for that purpose.

*porphyry, trap, jasper, petrosilex, flint, agate, quartz*, and various other ancient species. These are of every size from small gravel to *boulders* fit for street and court paving. They are not angular, but have suffered attrition, until the distinctive characters of many fragments are almost obliterated, and a fracture must be made before they can be known. They are blended intimately with the other stoney wreck, and have not hitherto been found to occupy any distinct bed. The source of this *debris* of primitive and transition strata can be best ascertained by tracing its distribution over the country. I have observed pebbles of this kind on the Hudson river at West Point, where the plain is composed in part of rolled fragments. But as they are in general larger than those found on the Ohio, less worn and polished, have a greater proportion of mica slate pebbles, which do not seem to bear rolling to a great distance, and are mixed with rubble from the sand stone mountains of Katskill, they should, I think, be considered as being detached from the adjacent primitive rocks. An additional reason for this opinion may be drawn from the silence of our excellent friend Professor Mitchill as to the *debris* of ancient strata among the alluvion of the upper parts of the valley of this river.\* It seems probable then that the currents which rolled and polished these fragments, did not extend laterally as far as the basin of the Hudson. We do not however depart from it westwardly but a short distance, before we meet with the ruins of primitive strata. An observing traveller, Mr. J. C. Warren, informs me that he saw them on the Chenongo, a branch of the Susquehanna, and observed them near all the streams in passing thence by the town of Erie on the lake, and along the Allegheny river to Pittsburg. Mr. Thomas Nuttall had previously noted the same thing during a journey in which he visited most of the principal rivers and lakes in the western part of New York. So much for the north-east. To the south-east and south, the valley of the Ohio seems to

\* See Medical Repository, Vol. I.

constitute the boundary of this *debris*. Beyond that river, there are indeed but few water worn pebbles of *any* kind ; and the narrow alluvions of the streams are generally argillaceous. I have travelled over most of the northern and north-eastern parts of Kentucky, and do not now recollect to have seen any foreign rolled pebbles. Mr. Warren has visited the north-western portions of the same State, and at my request was particularly attentive to this point, but did not discover any. The acute and observing Mr. Nuttall travelled through the centre of the same State from north to south on foot, but after leaving the valley of the Ohio opposite this town, he found none of these fragments until he approached the French Broad, in Tennessee, whose source is in a primordial formation. To the west and south-west, the currents of the great valley have transported the *debris* much farther. Mr. Nuttall has traced it only to the mouth of the river St. Francois ; but my late lamented friend Dr. Goforth met with it in the form of gravel, not many miles above Natchez. To the north-west, it was found by Mr. Nuttall on the Missouri, as far as the great bend at the Mandan villages, beyond which he did not ascend. From the mouth of this river to Erie in Pennsylvania, the same persevering naturalist met with it on the shores of all the rivers and lakes which he visited, and from the information which he has kindly afforded me by letter, it appears that this *debris* is larger and in greater quantities in that region than this. Within the limits here sketched, it is found in the vicinity of all the streams, and forms with the ruins of the surrounding strata the bases of all the fertile and level prairies. We are hence, I think, justified in the conclusion, that its origin was in the north, and that it was brought and deposited on the surface of this country by currents which in ancient times flowed from beyond the lakes to the Gulf of Mexico, and of which it may be regarded as the sign and effect.

A more recent formation than many of the alluvial beds contained within the limits just defined, is the stratum of loam

spread over the surface of our hills and valleys in an *overlying* position. This appears to be the same that in the north of Europe is denominated *geest*,\* and which Mr. De Luc considers as the last deposit made by the sea before its final retreat. Sir Humphry Davy regards the soil or friable argillaceous surface of Great Britain at least, as having resulted from the disintegration of the rocky strata underneath.† There are doubtless but few rocks that would not be mouldered by exposure to the action of the atmosphere, and where the waters, before their final retreat, made no protecting layer, the argillaceous surface may be fairly referred to decomposition. But there is much reason for believing that the greater part of the *geest* of this country has subsided from fresh water, and is a true alluvion. It varies considerably, I acknowledge, in different places, but its essential constituents, clay, sand, and yellow oxide of iron, combined in varying proportions, seem still to be present. It is indeed destitute of the remains of aquatic animals, and might not therefore be supposed to have had the origin here intimated; but the old alluvial beds which have manifestly been accumulated by water, either salt or fresh, are almost equally destitute of aquatic exuviae. On the other hand, it exhibits, in some places, an obscure stratification, it does not abound particularly in the undecomposed fragments of the rocks over which it is spread, its colour and density are nearly the same from bottom to top, and it envelopes, as we shall presently see, along with more or less gravel, large masses of adventitious rocks, conditions that sufficiently characterise it as a distinct and real *formation*. It has been washed by the rains into the lower parts of the valleys, where becoming blended with the recent alluvion of the streams, it encloses the bones of the arctic elephant, great mastodon, and other extinct quadrupeds. On the south side of the Ohio, it is only from four to eight or twelve feet deep; but to the

\* L' Histoire de la Terre et de l' Homme, tome v.

† See his Elements of Agricultural Chemistry.

north of that river, its thickness becomes so great, that the floetz limestone is but here and there seen projecting through it.

The deposition of the *geest* seems to have been the last operation which the waters of the north performed upon this region; and was of course subsequent to the excavation of the valleys, as no deposit could have remained upon their acclivities, while the agent which formed them continued its action. You are, Sir, already apprised, that to this formation belong the great blocks of foreign primitive, transition, and old floetz rocks, which have excited in travellers so much astonishment, and which, in one point of resemblance at least, approximate the region south of Erie, Huron, Michigan, and the other lakes, so closely to that which stretches from the southern shores of the Baltic sea.

These masses, in the neighbourhood of this place, are for the most part solitary, but in the interior of the State, it is not uncommon to find them grouped into heaps which are slightly covered with soil; and it is, I suspect, an aggregation of this kind, on one of the islands of Lake Huron, that a British officer mistook for granite *in place*.\* The size of these masses extends from that of gravel and pebbles to the diameter of eight or ten feet. The larger blocks are frequently found *upon* the old alluvial plains, but never, that I have understood, *within* them. Their geographical range is over the same region with the smaller foreign *debris* of our valleys, but more limited to the south west. I have never seen a single block on the opposite side of the Ohio, and am not informed that any have been observed lower than the thirty-ninth degree of latitude.

I do not entertain a doubt that these fragments were enveloped in large fields of ice in a region far beyond the lakes, and floated hither by the same inundations that brought down and spread over the surface of this country the *geest* in which they are imbedded. In the southern parts

\* See Thompson's Annals of Phil. for March, 1816.

of this formation, they are not found ; but this should be attributed to the influence of climate. The ice to which they were attached could not of course pass a certain latitude ; and from the great increase of these masses as we advance towards the north, it would seem that many of the ice-bergs suffered dissolution long before they arrived at this *maximum*. Future observers will no doubt trace them to their parent strata in the arctic regions, as Von Buck has traced those which are lodged on the shores of the Baltic. The ice islands of the Atlantic ocean may reasonably be supposed to bring down, and deposit on its bed in the Temperate Zone, primordial masses, similar to those spread over some parts of this and the European continent. These islands are, I believe, not often seen further south than the forty-first degree, near two degrees north of their southern boundary here. This is probably attributable to the gulf stream ; but for which, the larger tracts of ice would undoubtedly attain as low a latitude as the southern limits of the primitive blocks in this country : and hence a probable conclusion may be drawn, that the temperature of the northern hemisphere has undergone but little change since the remote epoch when this part of the continent was for the last time subjected to inundation.

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I shall, Sir, no longer employ you with my premature, and, I fear, abortive attempts at generalising some of the geological phenomena of this country. I have, indeed, occupied too much of your time in the discussion of points with which perhaps you were already better acquainted than myself.

I have drawn liberally on your patience, because the kindness which you have shown me at various times has inspired a hope, that you will excuse both the tediousness and temerity of my speculations. However this may be, I trust



you will at least perceive in them a manifestation of the profound respect with which I have the honour to be,

Sir,

Your obliged friend and servant,

DANIEL DRAKE, M. D.

His Excellency,

The Chevalier Joseph Correa de Serra,

Min. Plenipot. of the

Kingdom of the Brazils.